

Occupational and Environmental Lung Diseases: An Overview

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Chronic respiratory diseases other than lung cancer that are of occupational or environmental origin, along with cigarette smoking, account for over 100,000 deaths per year and are among the leading causes of respiratory disability in the United States and throughout the world. Lung cancer from these same exposures may account for 40,000 additional deaths per year. In spite of cigarette smoking's being recognized as the leading cause of both chronic obstructive pulmonary disease (COPD) and lung cancer, many other environmental and occupational exposures have been implicated as directly or indirectly associated with smoking in producing these diseases. In addition, the burden of disease is not uniformly distributed across the U.S. population. Furthermore, recognition of these associations with environmental and occupational exposures has done little in the last 20 years to reduce the burden of these respiratory conditions at the population level.

COPD is the fourth leading cause of death in this country and, with asthma, accounts for one of the major categories of health care expenditure by whatever criteria are used. While the role of cigarette smoking is well characterized in these diseases as is the overwhelming role of smoking as the major cause of lung cancer, the identification of research objectives that could lead to strategies for lessening the burden of occupational and environmental causes of these chronic respiratory diseases is well worthwhile.

For many years efforts to establish the number of people at risk in occupational settings have used estimates of employed and retired work forces in industries with known putative respiratory exposures.

Often for legitimate reasons, developing these numbers has been extremely difficult, and thus the estimates are crude. Nevertheless, the National Institute for Occupational Safety and Health data suggest that over 20 million Americans are exposed to potential respiratory hazards in the workplace. Table 1 summarizes crude estimates of some of the major agents and industries in which exposures are known to occur. None of these exposures would be surprises to either the scientific community or the lay public, yet they continue to occur. Added to these numbers is the potential for over 100 million citizens to be exposed to environmental irritants from primary air pollutants that exceed the National Air Quality Standards first established by the U.S. Environmental Protection Agency in 1971 in many parts of the country at least several times per year.

We approached this important topic by taking the view that it is critical to first understand the pathophysiologic, biologic, and general epidemiologic approaches that might be invoked in studying these diseases. Second, we explored the major environmental and occupational exposure patterns within the U.S. population. Finally, we selected the disease outcomes known to be associated with these exposures and asked experts to provide a selected review of the state of knowledge, to identify the important gaps in our knowledge, and to suggest avenues of research for the next 5–7 years.

This effort brought together a wide variety of knowledgeable scientists with diverse expertise from basic science to clinical applications and population sciences. Although each manuscript in this monograph was produced independently, all authors had a common objective.

Table 1. Selected agents and industries with potential for respiratory hazard exposure.

Agent	Industry	Estimated number of persons exposed	Chronic respiratory disease	Estimated risk
Asbestos	Construction, manufacturing, and mining of asbestos and related materials	~ 250,000 primary processing, 3×10^6 in secondary processing	Pulmonary fibrosis, obstructive airway disease, lung cancer	Asbestosis: 10–50%, lung cancer: 1–10%
Silica	Mining, stone cutting, construction, farming, quarrying	1.2×10^6 in nonagriculture	Pulmonary fibrosis, silicosis	0–13%
Cotton dust	Cotton mills	800,000	Chronic bronchitis, reduced pulmonary function, bysiosis	2–30%
Coal dust	Coal mining	200,000	Pulmonary fibrosis, pneumoconiosis	4–46%
Known chemical and biologic sensitizers	Wide variety of industries	$> 9 \times 10^6$	Occupational asthma	Up to 28% of adult asthma
Grain dust	Elevator agents, dock workers, longshoremen, mill workers, bakers	500,000	Occupational asthma, COPD chronic bronchitis	Up to 30% in non-smokers, perhaps up to 60% in smokers

This monograph is divided into three parts. The first describes some of the methods currently being used to study these diseases. In the second part, experts consider issues related to exposure to specific pollutants. The third calls on different experts to consider the common environmental and occupational diseases. This format of necessity leads to overlap, which was intentional. We chose to take advantage of slightly different perspectives brought to bear on a number of the topics covered. We would like to emphasize that all manuscripts submitted to *Environmental Health Perspectives* undergo peer review, including manuscripts in this monograph.

The reviews of each of the environmental and/or occupational settings are broad and clearly indicate the need for considerable research to fully understand the nature of the putative exposures and the strategies that might reduce the burden of these diseases. The recommendations for research contained in each review represent the judgment of the reviewer; however, some broad summary statements seem warranted.

With regard to a better understanding of exposure, clearly better measurement of chronic low levels of exposure across the range of environmental agents being considered would provide investigators with much-needed insight into the relation between exposure and chronic disease. These measurements need to be both broadly made and uniformly recorded and archived so they can be assessed in relation to potentially exposed population groups and, on an individual level, confirmed with biomarker data that will reflect chronic exposure. Models also need to be developed to assess the impact of mixtures of exposure, whether they are mixtures of multiple dusts, particles, and gases; allergens and nonallergenic materials; or specific chemical forms or elements of environmental and occupational agents.

We must improve our understanding of the pathophysiologic mechanisms of disease development. Through the use of animal models, detailed physiologic studies, human exposure studies, and

prospective epidemiologic studies designed to test mechanistic hypotheses, we should be able to develop strategies by which mechanisms can be identified. Interactions between host susceptibility and environmental or occupational exposures need to be explored in terms of gene–environment interactions. In addition, environment–host interactions that are altered by growth of the developing lung, aging of the lung, and changes in defense mechanisms resulting from smoking, infection, dietary factors, and the like must be considered.

An important aspect, unrelated to direct efforts of exposure in the lung, is the airways and lungs acting as portals of entry with potential direct or reflex effects on other organ systems. The classic occupational example is carbon disulfide exposure in the textile industry and the risk of cardiovascular disease. More recently efforts to understand the potential mechanisms underlying the observations of excess cardiovascular events associated with ambient environmental exposures have led to physiologic studies in animals, controlled clinical exposure studies, and population-based studies. In these studies the concepts of the lungs as a portal of entry for the direct transport of particles through the lung to the systemic circulation as well as potential cytokine release and autonomic nervous system stimulation are all being explored. Inherent in these efforts are a number of hypotheses relating mortality to lung disease mechanisms but also systemic responses and how these might be infringed upon of gene–environment interactions.

Absent from this exercise is a research agenda on abatement of these recognized exposures. This lack may be the result of the selection process by which the experts were chosen and charged to develop a research agenda for the next 5–7 years. We hope that by implementing suggestions made by these authors we will learn things that will be applicable to the development of abatement strategies to reduce the burden of these diseases.